Canada–B.C.
Conservation and Renewable Energy Demonstrations

B.C. 23

Energy, Mines and Resources Canada
Conservation and Renewable Energy Branch

Energie, Mines et Ressources Canada
Bureau de la conservation et des énergies renouvelable

Province of British Columbia

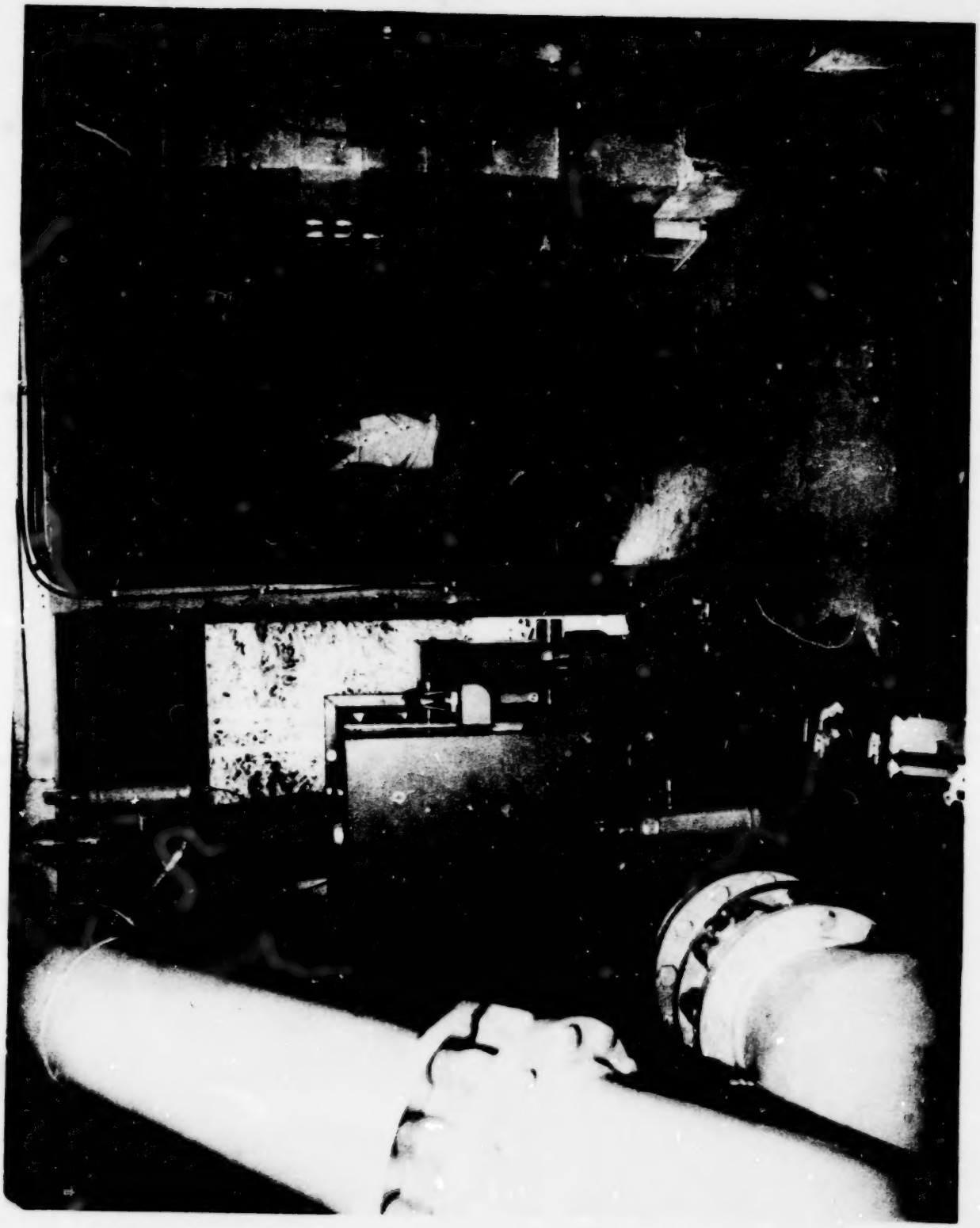
Ministry of Energy, Mines and Petroleum Resources
CONSERVATION AND TECHNOLOGY DIVISION

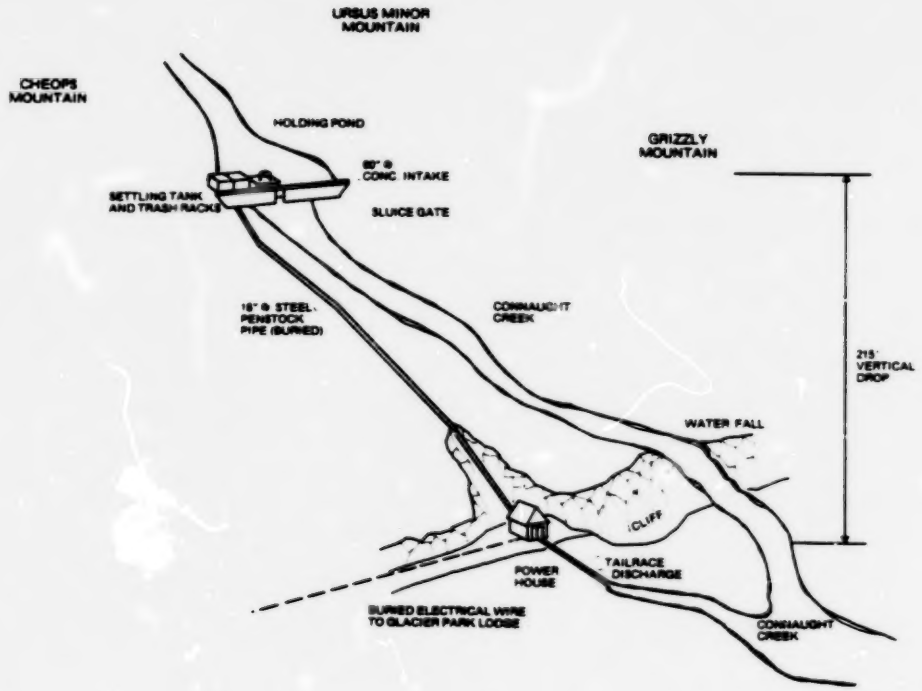
GLACIER PARK SMALL HYDRO DEMONSTRATION

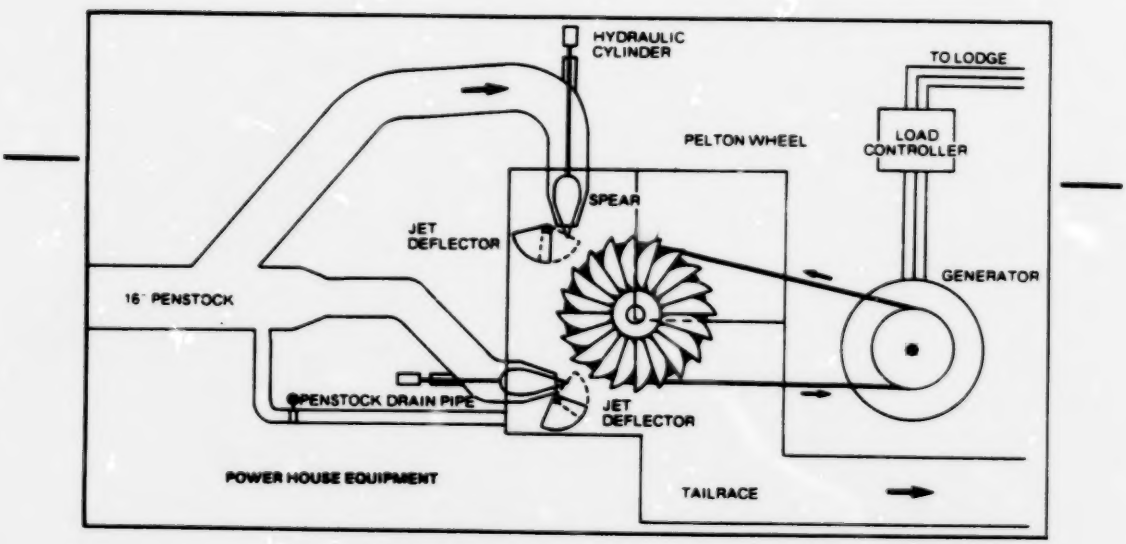
PROJECT EVALUATION REPORT

January 1984

Canada/B.C. Conservation and Renewable Energy Demonstration Agreement




URSUS MINOR MOUNTAIN
CHEOPS MOUNTAIN
HOLDING POND
GRIZZLY MOUNTAIN
60" ⌀ CONC. INTAKE
SETTLING TANK AND TRASH RACKS
SLUICE GATE
16" ⌀ STEEL PENSTOCK PIPE (BURIED)
CONNAUGHT CREEK
215' VERTICAL DROP
WATER FALL
CLIFF
TAILRACE DISCHARGE
POWER HOUSE
BURIED ELECTRICAL WIRE TO GLACIER PARK LODGE
CONNAUGHT CREEK


HYDRAULIC CYLINDER
TO LODGE
PELTON WHEEL
LOAD CONTROLLER
SPEAR
JET DEFLECTOR
GENERATOR
16" PENSTOCK
PENSTOCK DRAIN PIPE
JET DEFLECTOR
POWER HOUSE EQUIPMENT
TAILRACE

CANADA/BRITISH COLUMBIA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources - oil and natural gas - are becoming less accessible and more costly. However, Canada is well-endowed with non-renewable and alternative resources that can provide a bridge into the future.

To this end, the government of British Columbia and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement. The Agreement is dedicated to the development and demonstration of conservation and renewable technologies.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies within B.C.
- To create employment in new or existing energy-related industries.

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PROGRAM OBJECTIVES

The project demonstrates the feasibility of a "run-of-the-river" small hydro plant. Furthermore, it provides a working experiment to investigate the positive and negative economic and environmental impacts of such a project, especially since this project is located in a Federal Park (Glacier National Park). This project should induce any small industry located near an available appropriate water source to consider small hydro power generation as a viable alternate or supplementary energy source.

The installation will reduce the Lodge's fossil fuel consumption, primarily in the area of electrical power generation and secondarily to utilize excess power in the form of heat to supplement the output of the lodge's Cleaver Brooks 1.2 million BTU oil furnaces, which provide domestic and heating hot water.

GENERAL DESCRIPTION

HISTORY

Glacier Park Small Hydro Demonstration is located at Glacier Park Lodge on the summit of Rogers Pass in Glacier National Park.

The water for this project is provided by Connaught Creek, 500 feet from Glacier Park Lodge. Connaught Creek has historically provided a reliable domestic water supply for Glacier Park Lodge and Parks Canada's facilities at the summit.

Connaught Creek is fed by a drainage area of over 3,000 acres in a high precipitation region. Much of the potential run off remains locked in the form of snow for nearly six months of the year. During this low flow period the creek is supplied by springs welling up from general melt due to geothermal radiation. Since the drainage area is well insulated by snow throughout the winter months, this geothermal radiation provides a fairly stable release until spring thaw occurs. These colder months maintain a flow of 5-7 CFS while the warmer months maintain an average flow of 35-40 CFS.

Glacier Park Lodge, located on one of the most critical and dangerous sections of the Trans-Canada Highway, provides emergency service and accommodation to stranded motorists. As well the lodge is a Greyhound Bus Depot and 51 room full service hotel.

In the past, power has been provided for the Glacier Park Lodge by a 115 KVA generator powered by GM 671 diesel, with an identical set as back up.

POWER REQUIREMENTS

Power for the Glacier Park Lodge and adjacent service station (these are max. load figures) -

100 KVA produced by 671 diesel generator set

BREAKDOWN:

10 KVA to service station
90 KVA to hotel

FACILITY DESCRIPTION

Penstock

The facility consists of a powerhouse at the creek basin next to the highway with 442 m long 42 cm diameter steel supply line following the creek course to the "glory hole" intake in the original domestic water ponding area and dam located 64 m above powerhouse elevation.

Powerhouse

The powerhouse is a 15' by 25' concrete block structure designed in the same general A frame style as the lodge.

The turbine and generator set are mounted to a specially designed "floating" concrete floor so that any building settling will not affect the turbine's alignment in relation to the 42 cm penstock.

Water is exhausted from underneath the turbine through a tailrace and returned to Connaught Creek by way of a reinforced, contoured ditch, designed to minimize erosion to the surrounding marshland.

Technical Details

Basic Data:

Hydraulic static head	64 m
Demand flow	.38m^3/sec.
Penstock size	42 cm
Penstock length	442 m

Mechanical:

Capacity	150 kW
Wheel type	Peltech Pelton Stainless
Pitch diameter	50 cm
Shaft diameter	10.16 cm
RPM of wheel	600
Nozzle diameter (two)	9.5 cm, with spear valves and deflector
RPM of generator	1800
Type of generator	KATO, beltdrive, 600 V, 3 phase, 150 KVA

Automatic Control System

Thomson and Howe electronic load governor with water flow control and jet deflector control.

Theoretical Horsepower	270 HP
@ 75% plant efficiency	202 HP
Max. kW output	158 kW

Since the stream level is expected to vary from time to time and have seasonal variations with low water and the coldest months of the year, it is necessary that water flow to the turbine be adjusted so that efficient operation is maintained. The adjustment is accomplished through two spear valve nozzles which control the amount of water that reaches the turbine wheel. These spear valves are in turn controlled by a sensor which senses the dam at the intake. The water level sensor is a new invention which senses when one or more electrodes are immersed in water. There is a significant daily variation in water flow where night flows are less than day flows due to retardation of glacial melt at high altitudes. The water level sensor and spear valves are able to keep up with these variations in daily flow and thus eliminate the need to daily check the position of the spear valves.

A second automatic control system is used to control the speed of the wheel, or govern the wheel. This is done by very accurately sensing the frequency of AC current out of the generator. If the frequency drops below the 60 hertz then there is either not enough water or too much load, or if the frequency is above 60 HZ then there is too little load or too much water. Since it is

desirable to use the maximum amount of water available the automatic controller varies the load to the wheel thus governing the wheel and the generator at the appropriate speed. This is accomplished by varying the amount of power supplied to low priority loads. There are two low priority loads available. One is the Chromolox water heater in the basement of the Lodge which supplements the oil fired hot water heating system which heats the building. The second low priority load is the swimming pool in back of the Lodge. The power supply to these low priority loads can be continuously and minutely adjusted so that the total load on the water wheel is constant and thus the speed is constant.

There is a second means of governing the speed of the turbine and generator. If for some reason a low priority electrical load fails, the load controller will automatically activate the jet deflectors thus varying the amount of water which reaches the turbine. Since the jet deflectors interfere with the efficiency of the turbine they are less desirable and thus they are used only for back up if the low priority loads for some reason fail.

The jet deflectors have a second function. If there is sensed a significant underspeed or overspeed of the generator the jet deflectors will come full on and completely shut off the water to the turbine although allowing water to flow through the nozzles.

The automatic load controller made by Thomson and Howe of Kimberley, B.C. has an additional timekeeping capacity which allows it to keep track of the number of cycles gained or lost over a 24 hour period and automatically adjust the output of the generator higher or lower to compensate for this, thus keeping a very accurate control of 60 HZ average frequency out of the generator.

Monitoring Equipment

There are three kilowatt-hour meters currently installed at Northlander Lodge. The first one measures the energy generated by the small hydro plant at 600 volts. The second one mesures the energy dumped into the low priority Chromolox hot water heater in the basement of the building, and the swimming pool heater. The third one measures the amount of energy generated by the diesel generators.

Readings of all the kilowatt-hours meters are now being taken on a daily basis. A proper assessment of the economics of the Glacier Park small hydro installation will await the results of the meter readings over a period of time, especially over the winter months where low flows are expected and diesel use will increase and the heating requirements at the lodge are much greater.

PROBLEMS

As with any relatively new and experimental processes even the most carefully researched designs may prove to be less than desired, cumbersome or even unworkable, in the practical application. This project is no exception.

Rogers Pass experiences a most formidable winter, with one of the highest average snowfalls in Canada (average 33 feet annually).

Construction began on the powerhouse site and penstock trench in October and ground was frozen by early November. Consequently the penstock was not properly entrenched, especially at higher elevations near the reservoir. Due to very severe flood damage in this area the following summer the penstock was exposed for much of this length. During reconstruction of this area we were able to rectify the problem.

The original design of the intake called for a 6' diameter concrete culvert placed in the reservoir utilizing a 4' x 4' screened inlet on the side of the culvert. Water was directed from the culvert through a 24" corrugated pipe to an existing wooden settling box containing trash racks. The settling box was modified to house the intakes for both the penstock and domestic water supply. This proved to be unworkable as the much increased flow for the penstock intake, behind the domestic intake, caused severe debris build-up (i.e. leaves, sticks, etc.) on the trash racks required to filter the domestic water supply. This in turn caused a restricted flow to the penstock, a lower water level in the settling box than the reservoir and a severe vortexing at the penstock intake, resulting in reduced water pressure at the turbine. In addition the side intake of the concrete culvert was constantly being restricted by heavier debris such as rock and glacial silt.

These problems were corrected as follows:

A separate concrete settling box with trash racks was constructed for the domestic supply. The original wooden settling box was abandoned and the penstock intake was routed directly into the concrete culvert. The side inlet to the culvert was closed off, the top section removed from the culvert, a 1" x 1/4" flat bar screen with the slats arranged vertically with 1" spacing, the inside diameter of the culvert, was manufactured and suspended in the culvert above the penstock intake, to straighten the flow and prevent vortexing.

With the addition of the head level probe and an adjustable face log in the notch of the weir, correct water level is maintained above the new "glory hole" type intake.

The domestic settling box is provided with a separate intake, outside and below intake level of the culvert, preventing domestic water shortages. During spring and fall when there is a high incidence of floating debris a drum shaped screen with 1 1/2" openings is installed over the culvert. This allows the passage of finer debris and leaves, which do not affect the spear valves or turbine, but denies larger debris that could cause a blockage.

Larger debris, such as rocks and stumps, which may collect around the base of the culvert, can be washed out of the reservoir through a mechanical sluice in the base of the weir.

More recently, with the unusally cold weather experienced this winter a further problem has arisen. It appears that in sub-zero temperatures the Basler Voltage Regulator incorporated in the KATO generator and some deflector control relays do not function properly, allowing an uncontrolled overspeed situation to occur. We believe this problem can be overcome by better insulating the powerhouse and providing a higher output heat source.

On this particular Pelton Plant we have experienced main shaft sheave side bearing failure, twice, since installation. This may have been caused by improper installation or incorrect lubrication technique. Nothing conclusive can be offered as yet.

Minor problems include high sweating of the penstock manifolds, leaking spear valve air cylinders, water spray from the tailrace observation port during full deflection and the need to install a two way spring loaded valve on the top end air release to prevent suction during high flow.

BENEFITS

The obivous immediate benefit of this project is a reduction in fossil fuel consumption, both in the area of power generation and heating.

As well, the project has given Thomson and Howe, the supplier of most of the electronic controlling hardware and software, an opportunity to upgrade and refine many of their small hydro controls.

The experience and technical data being compiled by us should prove an asset to anyone interested in small hydro systems, and of course, we welcome all enquiries.

We also understand that at the time of manufacture, our turbine was the largest of its kind ever produced by Solace Energy Centres. Hopefully this has given Solace added knowledge and experience as well.

Since we are currently maintaining communication with all the suppliers and manufacturers involved in this project, as new problems or developments occur, there is a continuing exchange and growth of information. This has already and should continue to prove beneficial to anyone involved or interested in small hydro development.

ECONOMIC IMPACT

As well as the $335,000 shared by the contractors, tradesmen and suppliers who designed and built this project, we have realized the following savings in the reduction of fossil fuel consumption. These figures cover the periods from August 1982 to January 1983 (without hydro) and from August 1983 to January 1984 (with hydro). The comparison dates are calculated from August rather than May, the actual start-up date of the plant, because the original intake design problems (discussed in Problems) caused the plant to operate so haphazardly no meaningful figures could be compiled. We must also take into account that the hydro plant was

actually only supporting the hotel's full electrical needs until early October 1983. After this time electricity was provided by diesel generators and the full output of the hydro plant was diverted to assist heating. As operating experience and knowledge grows, in the future we will be able to increase these savings.

Total diesel fuel in litres for electrical generation

	Litres	Cost
August 1982/January 1983	92389.0	$29,102.50
August 1983/January 1984	57351.0	18,065.60
Savings	35038.0	11,036.90

Total diesel fuel for heating and hot water

August 1982/January 1983	84389.0	26,582.50
August 1984/January 1984	61631.0	19,413.70
Savings	22758.0	7,168.80
TOTAL SAVINGS THIS PERIOD	57796.0	$18,205.70

As you can see, for the first five months of operation, these figures are quite impressive and point the way to even greater savings in the future.

The Canada/B.C. Agreement paid $100,000 of the project costs and Northlander Lodge paid the remainder.

ENVIRONMENTAL PROS & CONS

Because of the severe flood damage experienced in the area, due to extremely heavy rains in early July 1983, all the true environmental impacts of the project are not yet discernable. However, some changes have been noted. Much of the foliage and trees immediately surrounding the diesel generating plant, which have been browned and damaged by 20 years of continual diesel exhaust, revitalized and produced new, fresh growth within days of the diesel plant shut-down. Lack of the constant groan of the diesel plant was readily noticable and appreciated by both our staff and guests. The area surrounding the roadway leading to, and around, the powerhouse has been landscaped and seeded and is in keeping with the nature of the Park. Since the drainage

ditch leading from the power house tailrace to Connaught Creek has been reinforced with rocks and boulders, the surrounding marshland shows no signs of unusual erosion.

The project has shown no detrimental environmental effects to date. If anything it has shown that it is possible to harness the power in nature without causing ecological or environmental damage.

RECOMMENDATIONS

1. That this report be updated in one year's time.

2. Any persons interested in small hydro development consult not only engineering firms and suppliers but get an on-site evaluation by individuals currently operating similar projects.

CONCLUSIONS

At the time of writing this the plant has been in full operation for only five months. It is therefore impossible to draw any conclusions on the long term effects of this project either economically or environmentally.

However, some observations are pertinent even in the short term. Since its inception and when construction began in October 1982, this project has drawn considerable attention from individuals and industry. People currently involved in small hydro production, such as McDonalds Lumber Ranch, have offered advice and criticism. As well, the Lodge has received enquiries from as far as Nova Scotia, from interested parties who are considering small hydro plants to augment or replace their current power generation methods and even one individual, who was considering small hydro for the specific purpose of selling electricity to the power grid.

Although this project has already provided benefits in the form of reduced fossil fuel consumption, we believe that as the system matures, with increased understanding and modifications both to the small hydro system and our own methods of operation we will realize even greater benefits.

This project has proven to be a success for all purposes intended.